Eur J Vasc Endovasc Surg **31**, 642–645 (2006)
doi:10.1016/j.ejvs.2005.11.018, available online at http://www.sciencedirect.com on SCIENCE DIRECT®

Use of a Pneumatic Tourniquet Improves Outcome Following Trans-tibial Amputation

A.M. Wolthuis, E. Whitehead, B.M.F. Ridler, A.R. Cowan, W.B. Campbell and J.F. Thompson*

Exeter Vascular Service, Royal Devon and Exeter NHS Foundation Trust and Peninsula Medical School, Exeter EX2 5DW, UK

Background. *It is traditionally taught that a pneumatic tourniquet is contraindicated for trans-tibial amputations in patients with peripheral arterial disease. However, tourniquets are used successfully during total knee arthroplasty in elderly patients. Vascular patients undergoing a trans-tibial amputation have a high perioperative mortality and morbidity—notably the need for wound revision or a higher amputation level. We hypothesised that a tourniquet, used during amputation, would reduce blood loss and subsequent complications without compromising healing.*
Methods. *This was a prospective non-randomized study of 89 adult patients who underwent a trans-tibial amputation between January 2001 and December 2003. The endpoints were: haemoglobin levels, the need for blood transfusion, perioperative morbidity, revision rate and mortality. Patients were divided into two groups: a group with a pneumatic tourniquet* (n=42) *and a group without* (n=47).
Results. *The haemoglobin fall was 14.8% in the non-tourniquet group and 5.6% in the tourniquet group, with a higher need for transfusion in the non-tourniquet group. The revision rate was 14.3% in the tourniquet group and significantly higher in the non-tourniquet group (38.3%). Mortality was similar in both groups: 7.1% for the tourniquet and 6.4% for the non-tourniquet group.*
Conclusion. *The use of a pneumatic tourniquet is safe and significantly reduces both blood loss and transfusion requirements during trans-tibial amputation. A pneumatic tourniquet reduces revision rates by over 50%, with subsequent cost savings.*

Keywords: Pneumatic tourniquet; Trans-tibial amputation; Below knee amputation; Blood transfusion.

Introduction

Trans-tibial amputation is a hazardous operation in vascular surgery, because the patients are elderly, usually unwell and have serious co-morbidity such as diabetes, renal failure and ischaemic heart disease, with many deaths due to myocardial infarction.[1] Bleeding is well known to be an independent predictor of perioperative mortality in surgery as a whole,[2] but even more so in vascular patients.[3]

Pneumatic tourniquets have been used for many years in orthopaedics and trauma. Patients undergoing knee arthroplasty are often elderly and have significant co-morbidity, particularly as an ageing population demands an operation which can help maintain their independence. Although most orthopaedic surgeons look out for severe peripheral vascular disease as a potential contraindication for tourniquet use, few actually measure ankle pressures and very few patients are referred for a vascular opinion. Despite this, there is no indication that liberal use of tourniquets leads to problems with wound healing, deep venous thrombosis or distal tissue loss. Bruce *et al.* concluded that it is safe to proceed with surgery using a tourniquet in patients with impalpable foot pulses or claudication, as long as the femoral pulse is palpable and there is no active ulceration or rest pain.[4]

We hypothesised that use of a pneumatic tourniquet might improve the outcome following trans-tibial amputation, without compromising wound healing in a population of elderly patients with atherosclerosis.

Methods

This was an audit of a pilot study where a standard orthopaedic tourniquet was used, inflated to twice the systolic blood pressure. The tourniquet was

*Corresponding author. Mr J.F. Thompson, Exeter Vascular Service, Royal Devon and Exeter NHS Foundation Trust and Peninsula Medical School, Exeter EX2 5DW, UK.
E-mail address: j.f.thompson@exeter.ac.uk

1078–5884/000642+04 $35.00/0

introduced for a trial period by each of three consultant vascular surgeons and initial impressions were discussed at weekly morbidity and mortality meetings. The technique was then shown to trainee surgeons; thereafter the choice of tourniquet was largely based on availability and personal preference. After approximately 100 amputations had been performed the outcomes were audited. Wound complications, revision, morbidity and deaths had been recorded prospectively and were verified weekly at a meeting of all three vascular surgeons and their teams. All patients' records were then scrutinised to revalidate these data. Blood transfusion data were obtained from the laboratory computer records and changes in haemoglobin concentration from the notes and computer records. Estimates of surgical blood loss are subjective and unreliable and were not included in the analysis.

A transfusion protocol was in force, with a trigger of 8 g/dL for vascular patients and a target haemoglobin concentration no less than 10 g/dL.

Differences were subject to analysis of variance; non-parametric data were analysed using the Mann–Whitney test. Categorical data were compared using the chi-squared test. It should be noted that the analysis was on an 'intention to treat' basis.

Results

Between January 2001 and December 2003, 89 patients underwent a trans-tibial amputation and 42 had a tourniquet applied. The patients' ages were a median 76 years (range, 41–88 years) in the tourniquet group and 72 years (range, 26–89 years) in the non-tourniquet group. All patients had end stage peripheral vascular disease (Fontaine III and IV). Patient demographics were well matched, with more males in the tourniquet group (Table 1). There were no complications associated with the use of the tourniquet and in particular no deep vein thrombosis or acute postoperative skin flap necrosis. The use of a tourniquet did not influence the above knee to below knee amputation ratio in our unit. We did use the tourniquet for Gritti Stokes and above knee amputations when possible, but the numbers were small and we wanted to study two comparable groups. In two patients with heavy arterial calcification and patent superficial femoral arteries, the tourniquet failed, so it was deflated to overcome the pure venous occlusion.

Table 1. Demographics

Group	Tourniquet	Non-tourniquet	*p*-Value
Number of patients	42	47	NS
Median age (years)	76	72	NS
Sex (M/F)	28/14	25/22	NS
Diabetes mellitus (%)	45.2	48.9	NS
Hypertension (%)	59.5	61.7	NS
Chronic renal failure (%)	4.8	4.3	NS

Table 2. Results

Group	Tourniquet	Non-tourniquet	*p*-Value
Haemoglobin fall (%)	5.6	14.8	<0.0001
Transfusion rate (%)	2.4	42.6	<0.001
Morbidity (%)	11.9	8.5	NS
Revision rate (%)	14.3	38.3	<0.025
Mortality (%)	7.1	6.4	NS

Mean preoperative haemoglobin was 11.3 g/dL in the tourniquet group *versus* 11.0 g/dL in the non-tourniquet group. The postoperative haemoglobin fall was 5.6% (to 10.6 g/dL) in the tourniquet group and 14.8% (to 9.3 g/dL) in the non-tourniquet group ($p<0.0001$). Only one patient (2.4%) was transfused two units of packed cells in the tourniquet group. In the non-tourniquet group, however, 20 patients (42.6%) needed a blood transfusion (Table 2). In total 47 units of packed cells were transfused; a median of one unit per patient. The need for transfusion was significantly higher in the non-tourniquet group ($p<0.001$).

Postoperative morbidity rates were similar in the two groups (Table 3). Six patients (14.3%) in the tourniquet group needed a stump revision and five of these went on to trans-femoral amputation (11.9%). In contrast, 18 patients (38.3%) in the non-tourniquet group needed a stump revision, and half of them required a trans-femoral amputation (19.2%). These postoperative revision rates were significantly higher in the non-tourniquet group compared to the tourniquet group ($p<0.025$). There was no difference in the grade of surgeon performing the original amputation in the subgroup requiring revision.

Three patients died in each group (tourniquet group 7.1% and non-tourniquet group 6.4%). One death was related to the primary amputation in the tourniquet group and two were in the non-tourniquet patients (Table 4).

Table 3. Morbidity

Group	Tourniquet	Non-tourniquet
Pulmonary oedema	1	
Pulmonary embolus	1	
Clostridium difficile diarrhoea	2	1
Acute myocardial infarct	1	1
Urinary tract infection		1
Cerebrovascular accident		1
Total	5 (11.9%)	4 (8.5%)

Table 4. Mortality

Group	Tourniquet	Non-tourniquet
Postoperative (30-day)	1	2
Death after revision procedure	1	1
Disseminated ovarian cancer	1	
Total	3 (7.1%)	3 (6.4%)

Discussion

The effect of a tourniquet on reducing perioperative blood loss during total knee arthroplasty is, somewhat surprisingly, unclear. There has been a trend towards the use of tourniquets to reduce blood loss and to give the surgeon a better perioperative view,[5,6] but recent reports question their effectiveness and there is also evidence against their use.[7,8] With regard to the timing of tourniquet release, three recent reports suggest that this should be done postoperatively.[9–11]

In varicose vein surgery a tourniquet reduces blood loss and improves cosmesis, without affecting complications or morbidity.[12–14] In the management of burns, tourniquets can be used without affecting skin graft viability.[15,16]

We acknowledge that selection bias may be present in this series, but reiterate that the decision to use a tourniquet was due to availability or simply remembering to use it. Patients with a high body mass index were not excluded from tourniquet use (they might be expected to have a higher complication rate). The differences in blood transfusion and revision rate were of such a magnitude that the advantages of the pneumatic tourniquet appear clear, but a randomised trial would support this impression.

Although, the tourniquet reduced transfusion requirements—a total of 45 units of blood in this series at a cost of £135 per unit—this did not translate into a reduction in cardiac morbidity, perhaps due to either a type II statistical error or falling rates of myocardial infarction, due to improved anaesthetic techniques and perioperative management. The overall mortality rate is gratifying when compared to published rates in the literature. Blood transfusion itself is associated with an increase in perioperative infection rates,[17] which may be one factor implicated in the higher revision rates in the non-tourniquet group.

Revision to a transfemoral amputation has major implications both for the patient, who is less likely to proceed to limb fitting and independence, and to the community, with the need for modifications to the home or even rehousing.[18] The precise reason why a tourniquet should profoundly improve revision rates was not addressed by this pilot study, but is a potent area for future research. The dry surgical field obtained with a tourniquet enables the surgeon to perform a neat, precise amputation without compromising skin flap viability. It may also reduce haematoma formation, which is a potent cause of stump breakdown. The only potential problem we can envisage is in the rare case of a functioning infra-inguinal vein graft, where it would be wise to avoid the use a tourniquet.

In summary, the use of a pneumatic tourniquet is safe and virtually eliminates blood loss and transfusion requirements during trans-tibial amputation, with no major drawbacks. Tourniquet use reduced revision rates by over 50%, with a subsequent benefit to the patient and cost savings to society.

References

1 Campbell WB, Marriot S, Eve R, Mapson E, Sexton S, Thompson JF. Factors influencing the early outcome of major lower limb amputation for vascular disease. *Ann R Coll Surg Engl* 2001;**83**(5):309–314.

2 Law S, Wong KH, Kwok KF, Chu KM, Wong J. Predictive factors for postoperative pulmonary complications and mortality after esophagectomy for cancer. *Ann Surg* 2004;**240**(5):791–800.

3 Tassiopoulos AK, Kwon SS, Labropoulos N, Damani T, Littooy FN, Mansour MA *et al*. Predictors of early discharge following open abdominal aortic aneurysm repair. *Ann Vasc Surg* 2004;**18**(2):218–222.

4 Bruce ASW, Getty CJM, Beard JD. The effect of the ankle brachial pressure index and the use of a tourniquet upon the outcome of total knee replacement. *J Arthroplasty* 2002; **17**:312–314.

5 Vandenbussche E, Duranthon LD, Couturier M, Pidhorz L, Augereau B. The effect of tourniquet use in total knee arthroplasty. *Int Orthop* 2002;**26**:306–309 [Epub 2002 August 02].

6 Wakankar HM, Nicholl JE, Koka R, D'Arcy JC. The tourniquet in total knee arthroplasty. The tourniquet in total knee arthroplasty. A prospective, randomised study. *J Bone Joint Surg Br* 1999;**81-B**:30–33.

7 Tetro AM, Rudan JF. The effects of a pneumatic tourniquet on blood loss in total knee arthroplasty. *Can J Surg* 2001;**44**:33–38.

8 Padala PR, Rouholamin E, Mehta RL. The role of drains and tourniquets in primary total knee replacement: a comparative study of TKR performed with drains and tourniquet *versus* no drains and adrenaline and saline infiltration. *J Knee Surg* 2004; **17**:24–27.

9 Christodoulou AG, Ploumis AL, Terzidis IP, Chantzidis P, Metsovitis SR, Nikiforos DG. The role of timing of tourniquet release and cementing on perioperative blood loss in total knee replacement. *Knee* 2004;**11**:313–317.

10 Hersekli MA, Akpinar S, Ozkoc G, Ozalay M, Uysal M, Cesur N *et al*. The timing of tourniquet release and its influence on blood loss after total knee arthroplasty. *Int Orthop* 2004;**28**:138–141.

11 Schuh A, Hausel M, Salminen S. Die Auswirkung der Oberschenkelblutsperre auf den Blutverlust in der Knieendoprothetik (Effect of tourniquet use on blood loss in total knee arthroplasty). *Zentralbl Chir* 2003;**128**:866–870.

12 Thompson JF, Royle GT, Farrands PA, Najmaldin A, Clifford PC, Webster JHH. Varicose vein surgery using a

pneumatic tourniquet reduces blood loss and improves cosmesis. *Ann R Coll Surg Engl* 1990;**72**:119–122.
13 Sykes TCF, Brookes P, Hickey NC. A prospective randomised trial of tourniquets in varicose vein surgery. *Ann R Coll Surg Engl* 2000;**82**:280–282.
14 Rigby KA, Palfreyman SJ, Beverle C, Michaels JA. Surgery for varicose veins: use of tourniquet. *Cochrane Database Syst Rev* 2002; **4**:CD001486.
15 Djurickovic S, Snelling CFT, Boyle JC. Tourniquet and subcutaneous epinephrine reduce blood loss during burn excision and immediate autografting. *J Burn Care Rehabil* 2001;**22**:1–5.
16 O'Mara MS, Goel A, Recio P, Slater H, Goldfarb IW, Tolchin E *et al*. The use of tourniquets in the excision of unexsanguinated extremity burn wounds. *Burns* 2002; **28**:684–687.
17 Mynster T, Christensen IJ, Moesgaard F, Nielsen HJ. Effects of the combination of blood transfusion and postoperative infectious complications on prognosis after surgery for colorectal cancer. *Br J Surg* 2000;**87**:1553–1562.
18 Campbell WB, St Johnston JA, Kernick VF, Rutter EA. Lower limb amputation: striking the balance. *Ann R Coll Surg Engl* 1994; **76**:205–209.

Accepted 18 November 2005
Available online 19 January 2006